CPST Tank & LAD Overview

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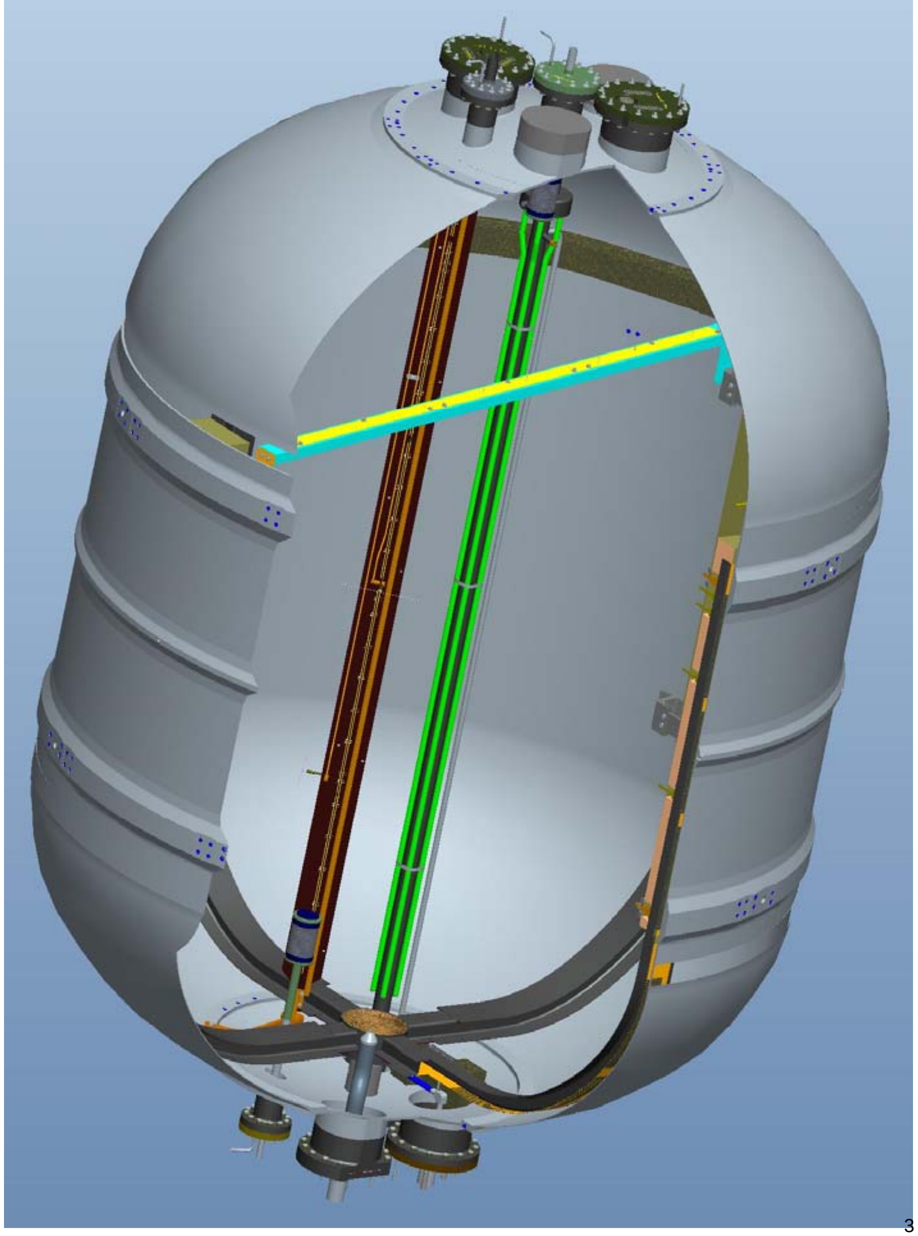
Overview

- Storage Tank
  - Dome forgings (3) procured from Spincraft; final machining done at MSFC
  - Barrel forging (1) procured from Ladish; final machining done at MSFC
  - Cost and schedule associated with procurements available upon request
- Transfer Tank
  - Aluminum forgings "bought" from test lab; previously owned by the RSRB project office
  - Final machining done at MSFC
- COPVs
  - Liners procured from SamTech; composite materials procured separately
  - Machining to be done at MSFC
- Storage Tank LAD
  - Screen channel gallery arms

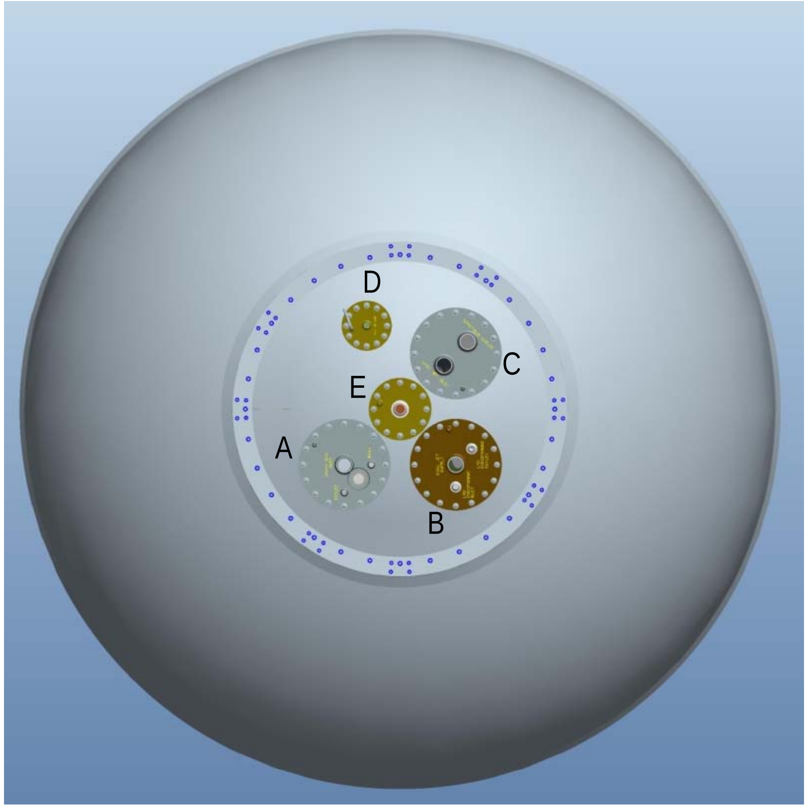
Storage Tank

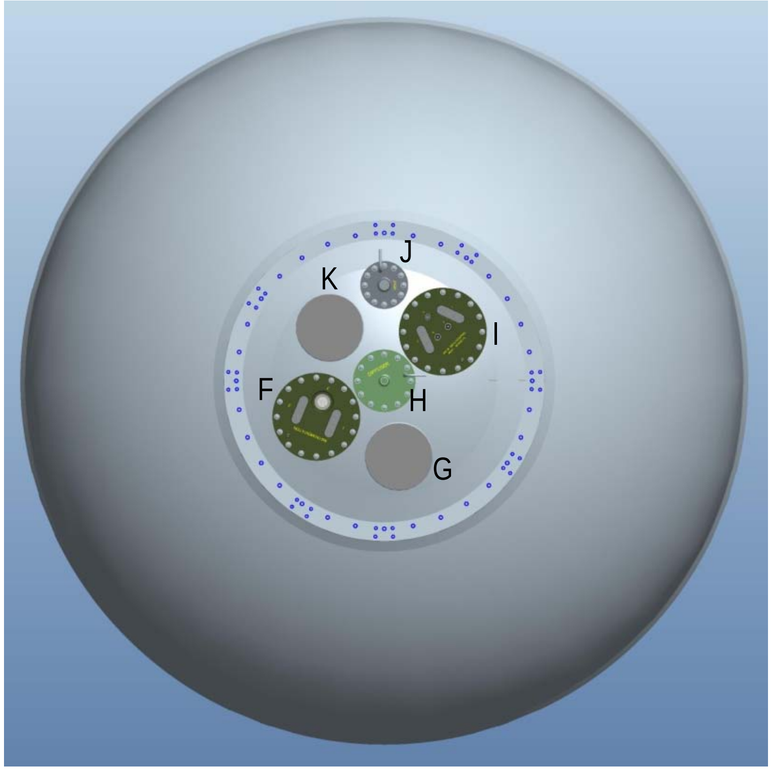
- Factors of Safety: 1.25/1.5
- MDP: 55 psi
- Tank Mass: 419 lbm
- Dome Material: 2219-T6 Aluminum
- Barrel Material: 2219-T8x Aluminum
- Manhole Cover Material: 2219-T851 Aluminum
- Root2 Elliptical domes
- Internal volume ~ 150.2 ft^3
- Overall Tank Dimensions: ~92.3" x ~67.4" ADD FEET
- Barrel height: 39.5"
- Manhole cover diameter: 24"
- C-Seals used on flange interface
- Stiffener attach bands used to provide thicker material for attaching inserts for bolting on attached components

- Detailed wall thicknesses in separate presentation
- Additional design details, data and calculations in separate presentation



Storage Tank Details





Forward Dome

Aft Dome

A: Spray Bar

B: LAD Conditioning Inlet/Outlet

C: Axial Jet

D: Transfer Return

E: LAD Outlet

F: Instrumentation Port

G: Camera Light Source Port - now capped

H: Pressurization Diffuser

I: Temp Rack/Cat Probe/Cryo Tracker/RFMG

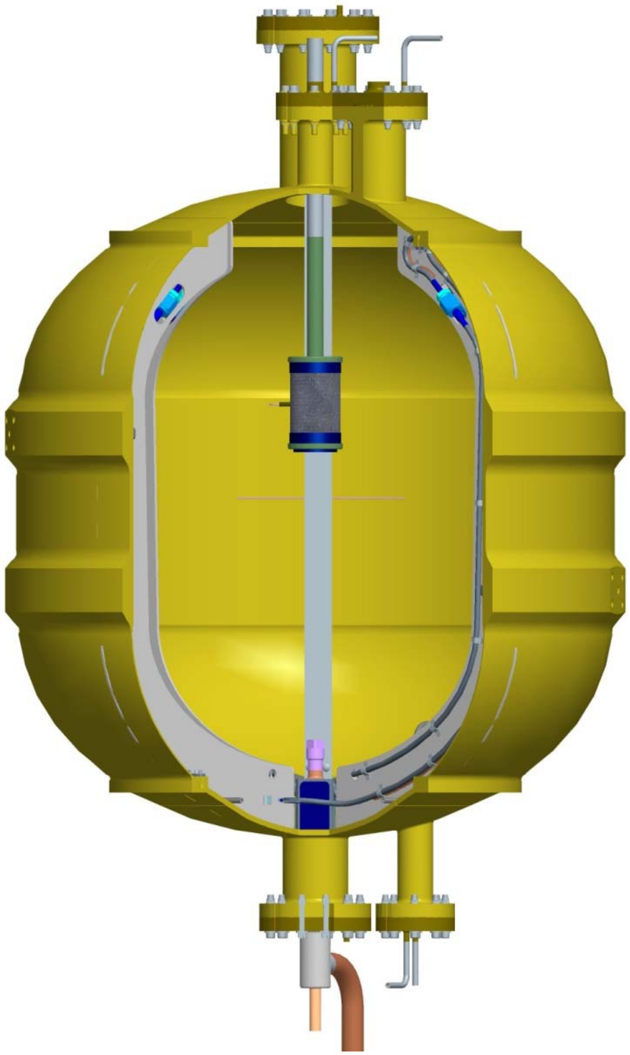
J: Vent Port

K: Camera Port - now capped

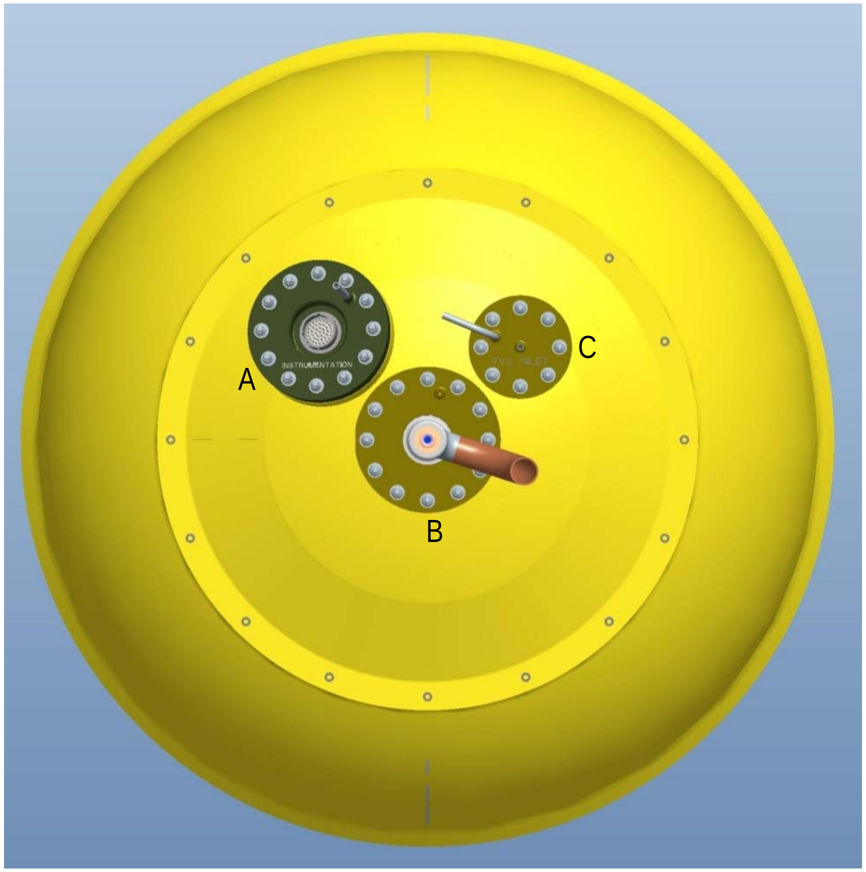
Transfer Tank

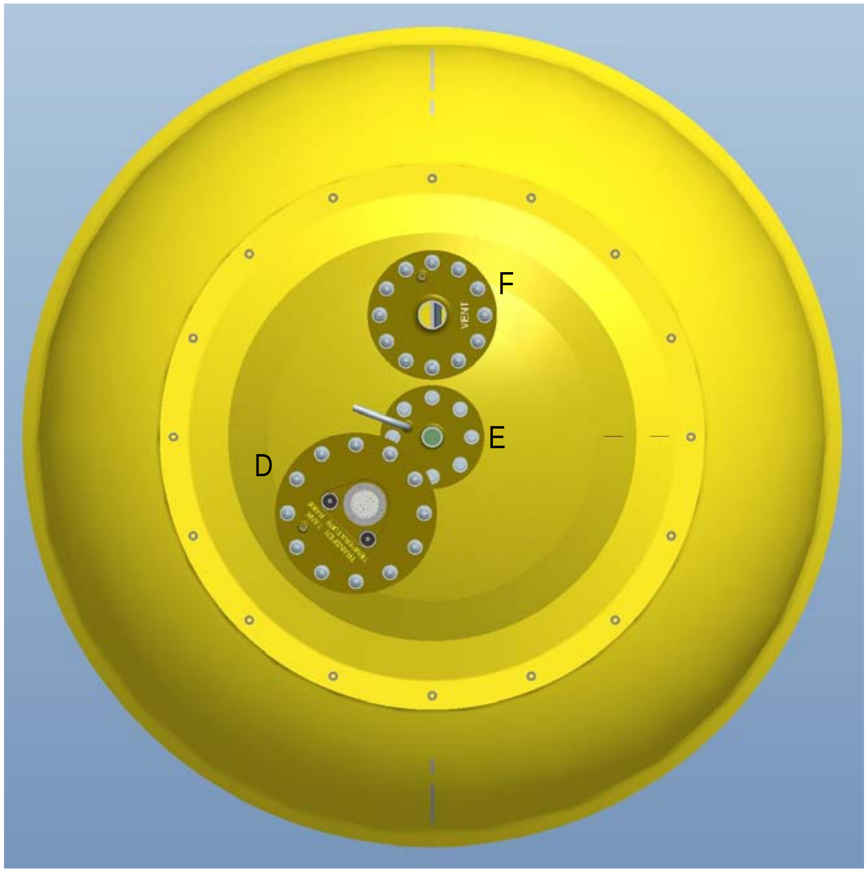
- Factors of Safety: 1.25/1.5
- MDP: 55 psi
- Tank Mass:~ 79 lbm
- Tank Material: 2219-T352 Aluminum
- Root2 Elliptical domes each with integral barrel
- Internal volume ~ 7.7 ft^3
- Overall Tank Dimensions: ~31" x ~28.5"
- Manhole cover diameter: 14"
- C-Seals used on flange interface
- Stiffener attach bands used to provide thicker material for attaching inserts for bolting on attached components
- Vane PMD details covered in separate presentation

- Detailed wall thicknesses in separate presentation
- Additional design details, data and calculations in separate presentation



Transfer Tank Details





<u>Aft Dome</u>

A: Instrumentation

B: LAD Outlet

C: Conditioning Tube Outlet

<u>Forward Dome</u>

D: Temp Rake/RFMG

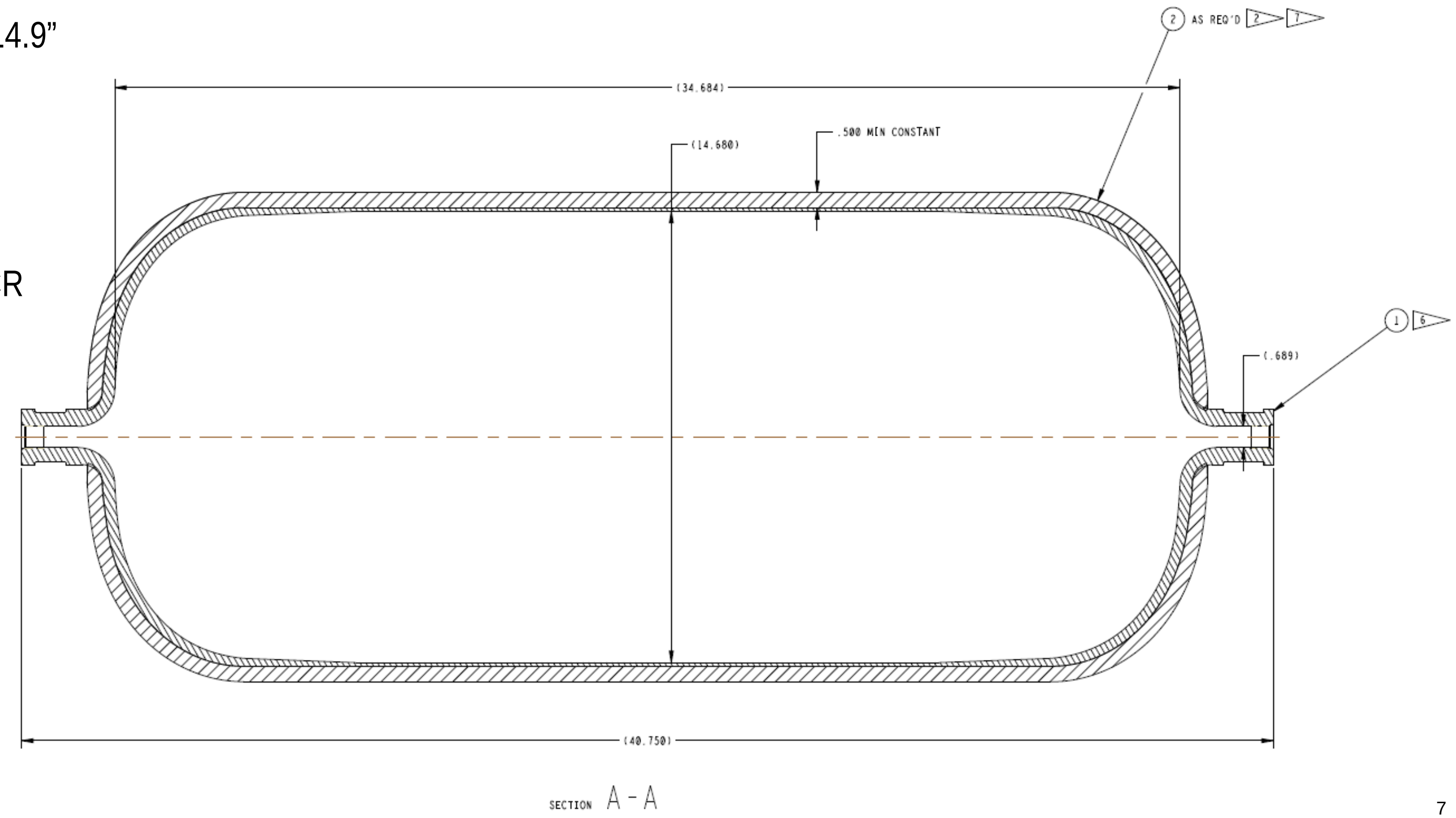
E: Diffuser

F: Vent Port

COPVs

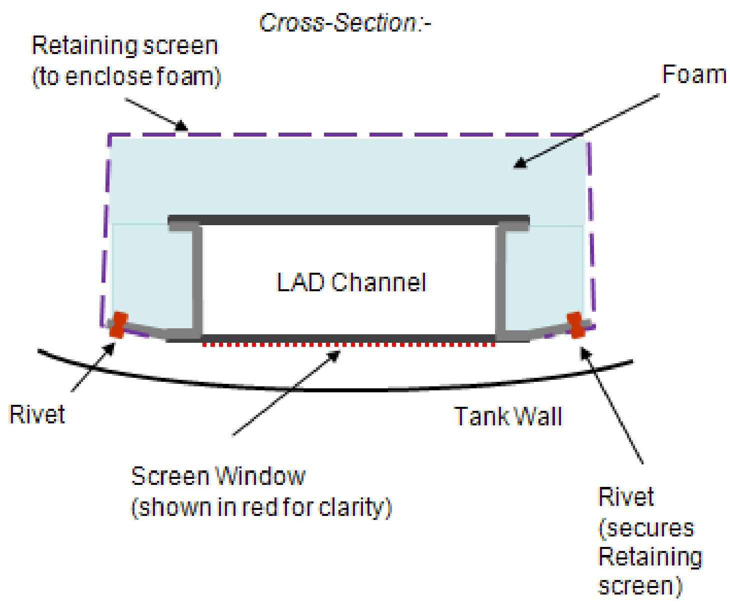
- CPST GTA will incorporate 4 COPV tanks to accommodate 12 ft^3 of GHe
  - Planned operating temp: -100F (blowdown min)
  - Volume set at 50% needed for flight estimates at the time of design
- Each COPV will have approximately 3 ft^3 internal volume
- MEOP/MDP: 4500psi
- Factor of Safety: 2.35/burst
- Liner outer diameter: ~14.9"
- Liner thickness: ~0.12"
- Port diameters: ½"
- Fiber: T800 from Toray
- Resin: UF3325 from TCR Composites

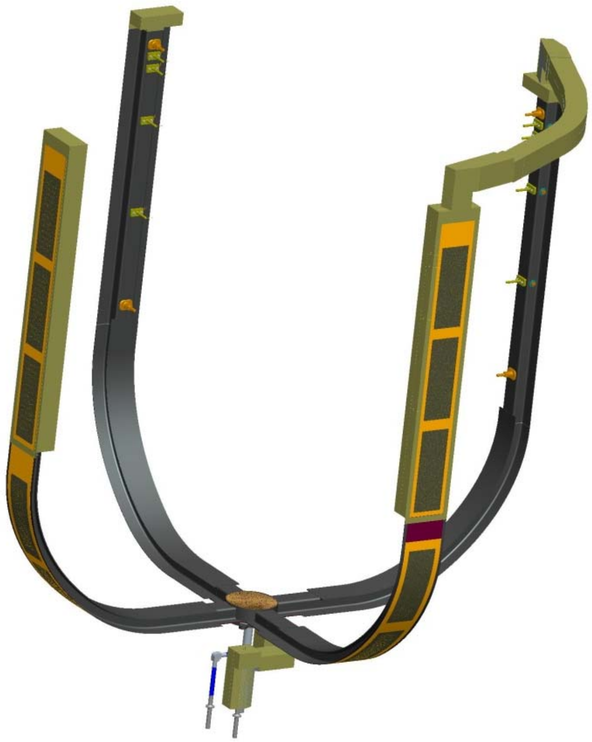
- In-house manufacturing was to be done by EM43
- Testing was to be performed by ER33 and Authorized Testing, Inc.
- Design according to ANSI/AIAA S-081A
- Overwrap thickness was to be finalized after initial pressurization testing

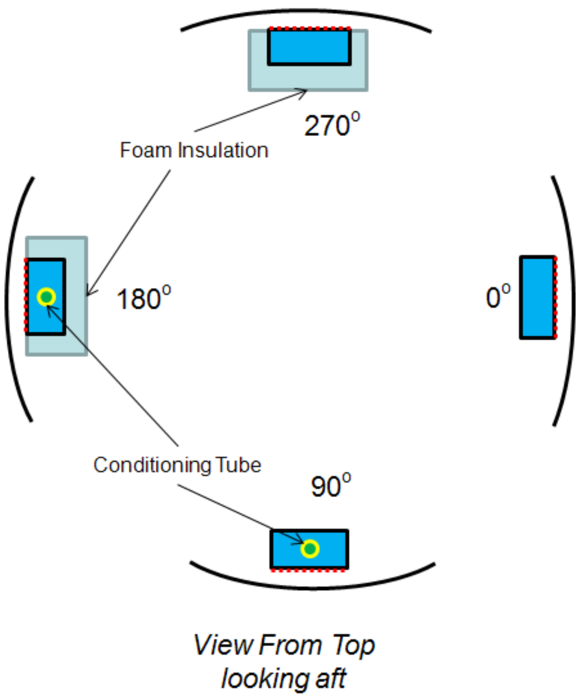


Storage Tank LAD

- Utilizes screen channel gallery arms
- Screen size: 325x2300. Based on seam welding capability
- Truncating LAD arms at the top of the barrel would allow us to collect data for a longer period of time before the arms break down
- 4 different LAD configurations to determine best method for mitigating heat transfer into LAD arms







Lessons Learned

- AIAA-S-080
  - Understand "special provision" if no qualification test is planned
    - "Proof test of each flight unit to a minimum of 1.5 times MEOP," which implies at least 2.0 ultimate SF (burst factor)
    - Consistent with Air Force range safety requirements (AFSPCMAN 91-710V3)
  - Make determination on whether Leak Before Burst (LBB) is required as part of early SRR
    - Safety aspects and robustness vs. weight penalty

- Recommend proof test and cryo-shock leak tests be conducted in support structure that simulates flight-like interfaces and boundary conditions (e.g., perform tests with tank supported from flight-like struts)
  - Provides some degree of test verification of flight-like pressure and thermal-induced loads at the support boundaries
  - Helps avoid the possibility of non-flight-like GSE interfaces causing critical design margin conditions as had to be addressed with the GTA Multi-Purpose Handling Fixture
  - Reduces chances for miscommunication and missed information for multiple interfaces

- Ensure that minimum drawing thicknesses are greater than the minimum thickness for the proposed NDE inspection method (recall storage tank dome minimum drawing thickness 0.070" was less than minimum required for standard dye pen 0.075")
  - Increasing the limit on minimum thickness may also help reduce the risk of machining nonconformances

Lessons Learned

- Recommend definition of structural load cycle plan and schedule immediately upon flight project ATP to include roles and responsibilities, deliverables (e.g., dynamic models, design loads, etc.), and milestones (e.g., design load updates and when the launch vehicle provider begins to participate in the load cycles).
  - See NASA Lesson Learned 0815, http://www.nasa.gov/offices/oce/llis/0815.html

- Need to identify component loads or load factors as soon as possible to minimize late design impacts
  - Critical input to several structural analyses

- Need to identify transportation & handling environments as soon as possible to minimize late design impacts
  - Critical input to several structural analyses

- Recommend thermal and structural study of strut configuration/orientation early in design phase
  - GTA strut orientations were established based on pre-phase-A study, but required subsequent modification to address dynamic and load issues
    - Dynamic issues never fully addressed because hardware for ground test only

- Recommend rigorous and accurate mass properties accounting from beginning of project (e.g., use mass properties capabilities in CAD software and other techniques)
  - Mass properties are critical input to several structural analyses

Lessons Learned

- Recommend all-welded ports (tank penetrations) rather than static seals to essentially eliminate leakage concerns
  - If bimetallic transition joints used, recommend bimetallic tube-type rather than flange-type based on technical maturity, commercial availability, cost, and schedule lessons learned on GTA

- Recommend elimination of LN2 from test and design environments
  - Most critical GTA load cases were for LN2 because of thermal loading plus head pressure
    - For flight, do not want design driven by a critical load case that is a ground test case

- Recommend increased amount of material characterization or material property confirmation (e.g., stress-strain curves) early in the design development schedule
  - For GTA, many properties were estimated from External Tank data and other available sources, but not confirmed -- the room temperature stress-strain curve for the dome material was not acquired until the thickness nonconformance assessment

- Require basic documentation of analysis and margins before signing drawings no matter how aggressive the schedule
  - GTA tank analysis (EV31) deferred stress notes and peer review, which increased risk of not catching errors
  - Lack of basic documentation makes it much harder to transfer or subdivide ongoing analysis task to different analysts if necessary

Forward to Flight

- Flight tank lessons learned and manufacturing capabilities will be covered in more detail in Matt Pruitt's Manufacturing presentation

- Manufacturing and assembly has proven the need for man-hole covers in the tank design
  - LAD & component installation
  - Internal access for NDE inspection

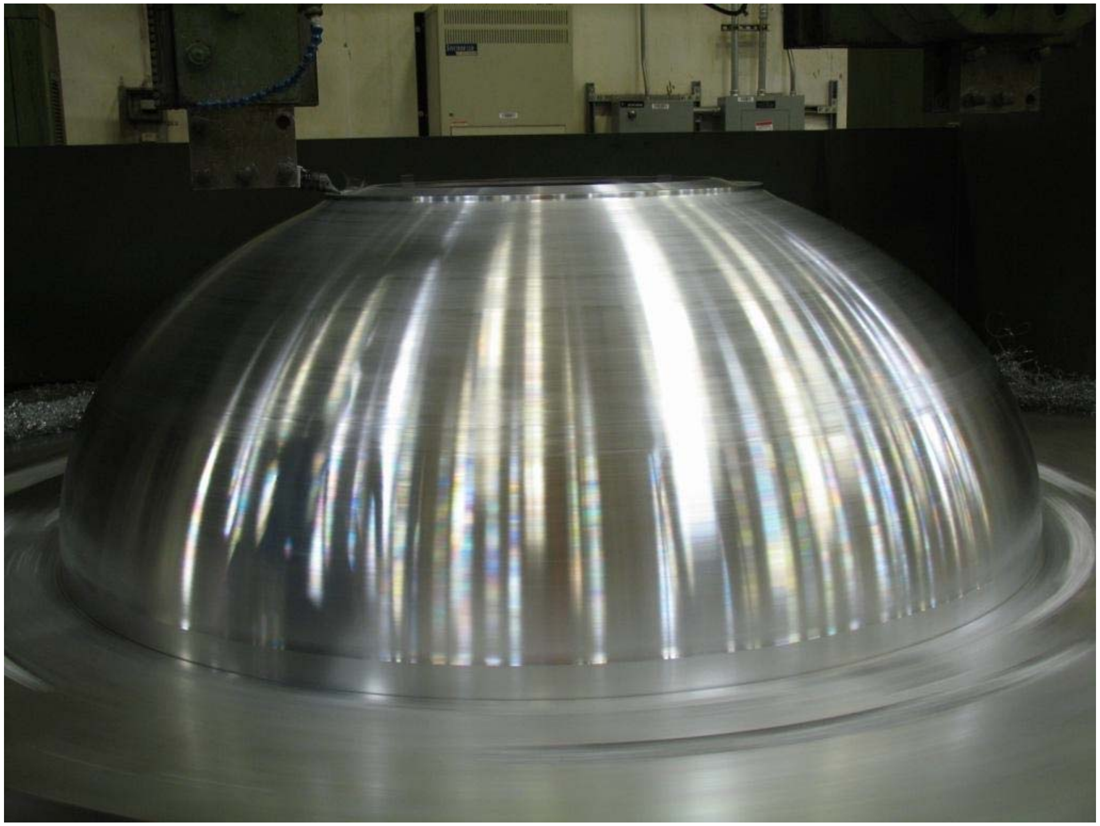
- Tank design & integration (complexities involved with idea of procuring "tank shell")
  - LAD
  - Wiring
  - Internal access for NDE
  - Intermediate levels of acceptance testing
  - Load effects from internally and externally mounted components
  - Differential contraction between different components of different material (pressure and temperature growth effects)
  - Integration into test facility vs. integration into test facility + spacecraft

- Needs to be a clear understanding of what "just-in-time" engineering means (concurrence engineering)

Backup

Storage Tank

Storage Tank Bottom Dome

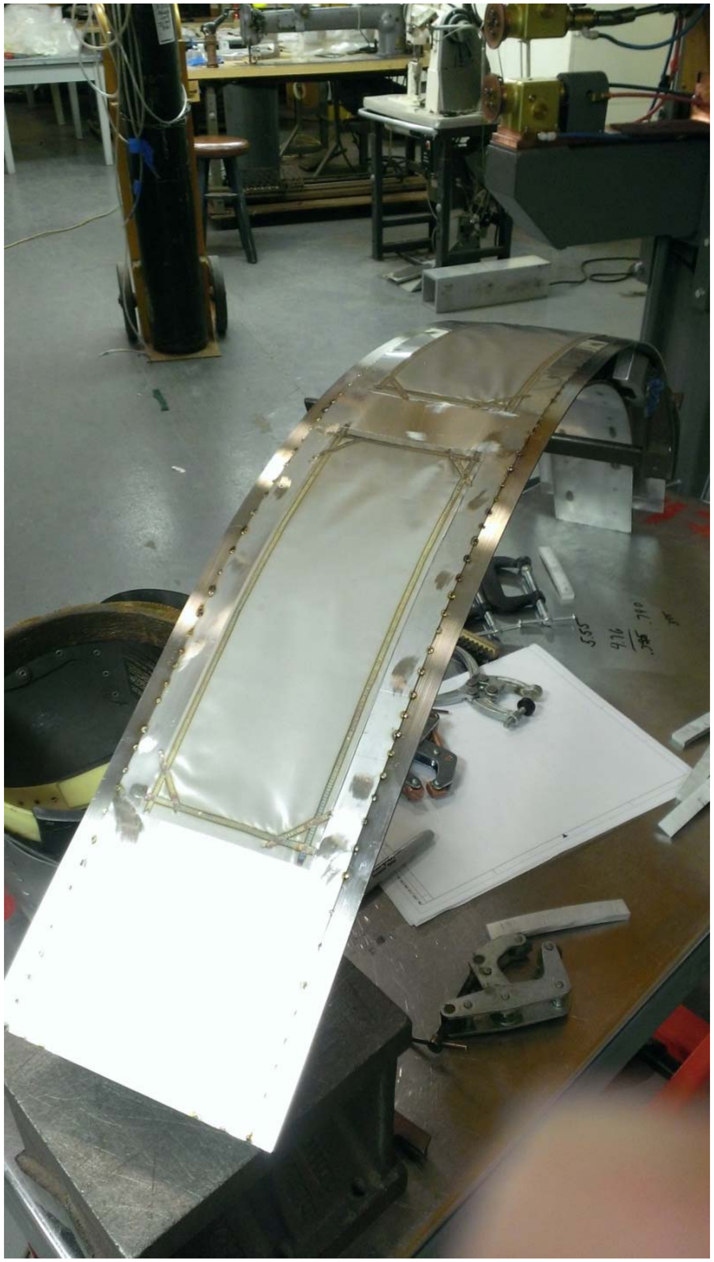


Forgings used for Transfer Tank

Transfer Tank Domes

Curved Arm Perf Plate/Screen Assembly

Curved Arm Tack Welded Assembly



Storage Tank LAD Straight Sections

Assembled LAD Straight Sections